Tonal Scale Simulation Study -

2.3 Gamma GEMS

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General

In an effort to improve both the resolution and contrast of GEMS, it has been suggested that a positive master transparency be employed in the simulation process with a cascaded processing gamma greater than unity. The resolution and contrast of such masters would be improved over that which is obtainable by printing a master to a cascaded gamma of unity from an original negative with a gamma of 2.3. However, high gamma masters would require that a new technique be developed in order to predictably control the convolution of modulation transfer functions, MTF, in a non-linear sensitometric system.

The desired sensitometric curve is another parameter of the simulation process that cannot be ignored when discussing the contrast of GEMS. A brief sensitometric study was performed which demonstrated that the contrast of mission material is simulated best when both the original negative and master transparency receive unity gamma one step processing. Further investigation is required in order to determine the resolution that would result for the optimum conditions of contrast.

MTF Simulation Technique

The formal procedure established for controlling the shape and radius of a spread function has been to generate a positive GEMS master transparency with a cascaded processing gamma

of unity. The spread function of the GEMS instrument mask can be convolved with the spread function of the GEMS master without introducing nonlinearities; since, over the straight line portion of the sensitometric data, the transmittance of the master is linearly proportional to ground exposure. If a positive master transparency, possessing a cascaded gamma other than unity, is employed, the nonlinearities associated with the sensitometric data must be accounted for in the prediction of the negative GEMS spread function. The procedure required to control the convolution of spread functions in a nonlinear system may be complex.

Sensitometric Study

Before investigating whether it would be possible to predictably control a nonlinear convolution of spread functions, a brief study was performed to determine the sensitometric behavior of the negative GEMS' scene density range. On the basis of maintaining a negative GEMS cascaded gamma of 2.3, a number of tone reproduction cycles were established for the hypothetical original negative gammas of 2.3, 1.0, and 1.4. The GEMS master sensitometric input values were positioned on the master's tone reproduction cycle to yield the maximum scene density range. The maximum density of the GEMS master was positioned on the tone reproduction cycle of the negative GEMS to print out as a typical base plus fog value.

In the different Case studies, the gamma sequence following the Case identification title indicates the one step processing

gammas for the original negative, the GEMS master, and the negative GEMS, respectively. (The sensitometric curves presented in this report are those published in the Eastman Kodak "Manual of Physical Properties.")

(1) Case I with gammas 2.3, 1.0, and 1.0.
Reference - Figures 1 through 4.

For the first tone reproduction cycle, it was assumed that an original negative with a gamma of 2.3 was employed to generate a master with a cascaded gamma of 2.3 The unity gamma processing was repeated again for the negative GEMS' cycle. By referencing the cascaded curve in Figure 4, it becomes apparent that the maximum GEMS' density achievable is 1.3 and the minimum exposure range is compressed, extremely.

On a theoretical basis, the calculated cascaded gamma for the sensitometric curve involved is 2.3. However, due to the regions of the sensitometric curves employed, the resulting cascaded gamma is only 1.8.

(2) Case II with gammas 1.0, 1.0, and 2.3.
Reference - Figures 5 through 8.

The Case II sensitometric considerations yields the highest negative GEMS density range and still

maintains the approximate sensitometric curve shape required. The 1.95 density range of Figure 8 can be increased to a density range of 2.10 by adjusting the maximum density value of the master to print at a base plus fog value of .14 instead of .10 on the negative GEMS film.

(3) Case III with gammas 1.4, 1.35, and 1.4.
Reference Figures 9 through 12.

The third Case study demonstrates that the exposure range in the toe and shoulder areas of the cascaded sensitometric curve become compressed when the one step processing gamma of each photographic step is made greater than unity. Note that the maximum density of the negative GEMS is less than that obtainable in Case II.

(4) Case IV with gammas 2.3, 2.3, and 2.3.
Reference Figures 13 through 16.

Case IV represents the combination of one step processing gammas that yields a negative GEMS density range equivalent to that of mission material. Scenes processed in this nature would be composed of basically black and white imagery with very little gray scale information.

Conclusion

It appears possible to improve the previously achieved negative GEMS' density range from approximately 1.0 density units to 2.0 density units by the gamma sequence described in Case II. To actually simulate the appropriate mission material sensitometric curve by a simple modification of the simulation technique is virtually impossible. The sensitometric study indicates that the films employed in the master and negative GEMS printing cycles must be capable of preserving the original negative sensitometric relationship. Commercial film exists to reasonably accomplish the task; however, both the resolution and granularity requirements of the GEMS will not be achievable.

Although the processing cycle sequence described in Case II will improve the appearance of GEMS, the deficiencies of this sensitometric sequence are the following:

(a) it is possible for the density range of mission material to exceed the density range of the negative GEMS.

(b) for the Case study cascaded curve shown in Figure 8, the low exposure region of negative GEMS is compressed to a greater degree than actually exists in mission material. The same condition will exist for the high exposure region of GEMS as they approach an over-exposure classification.

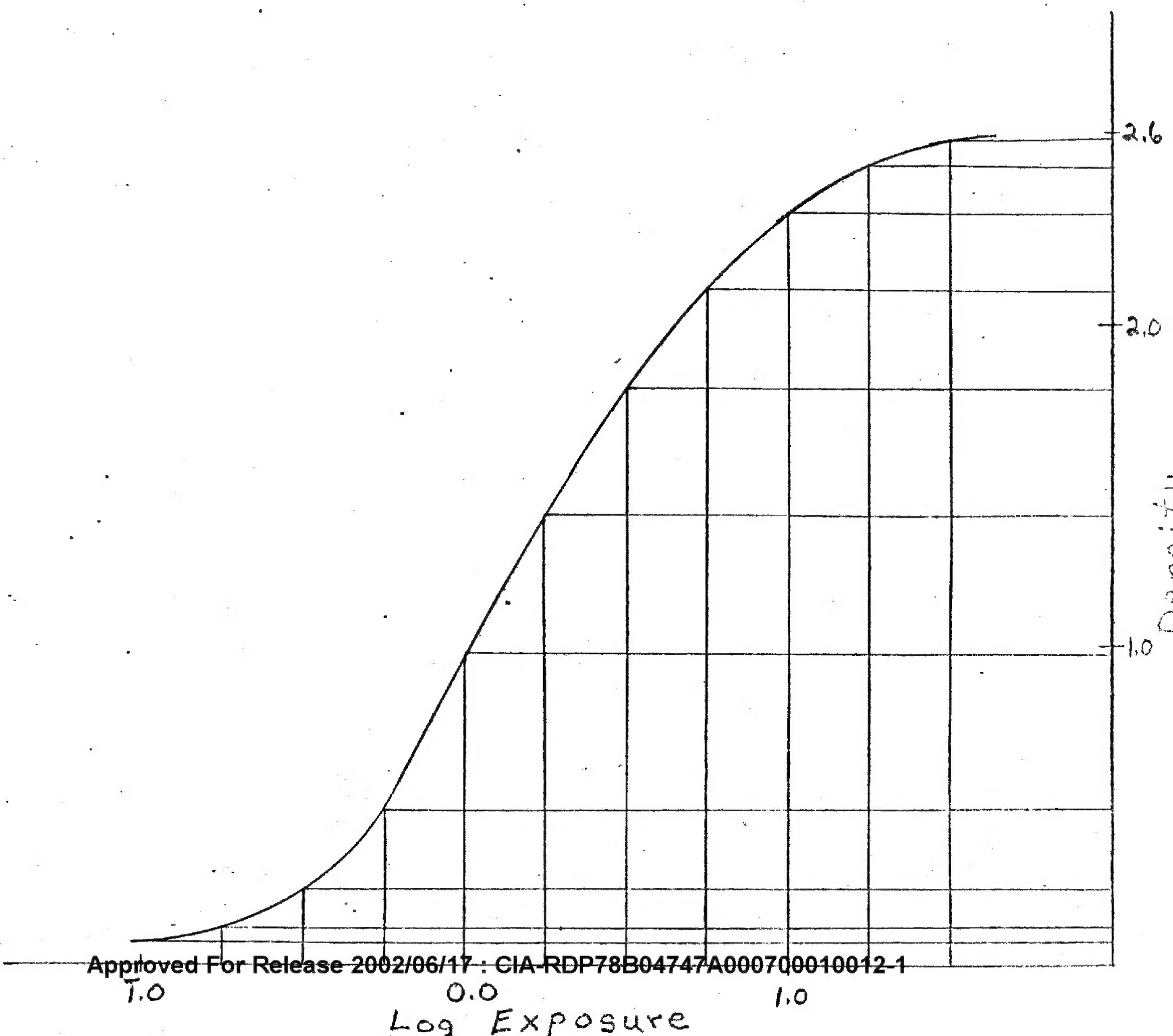
(c) in a simulated exposure series, part of the sequence of GEMS will appear to have their maximum density values approach the maximum densities of normal exposed mission material before truly representing an over-exposure situation.

(d) when a GEMS actually represents an over-exposure of mission material, the base plus fog level of the negative GEMS will be much higher than that of the mission material.

(7)

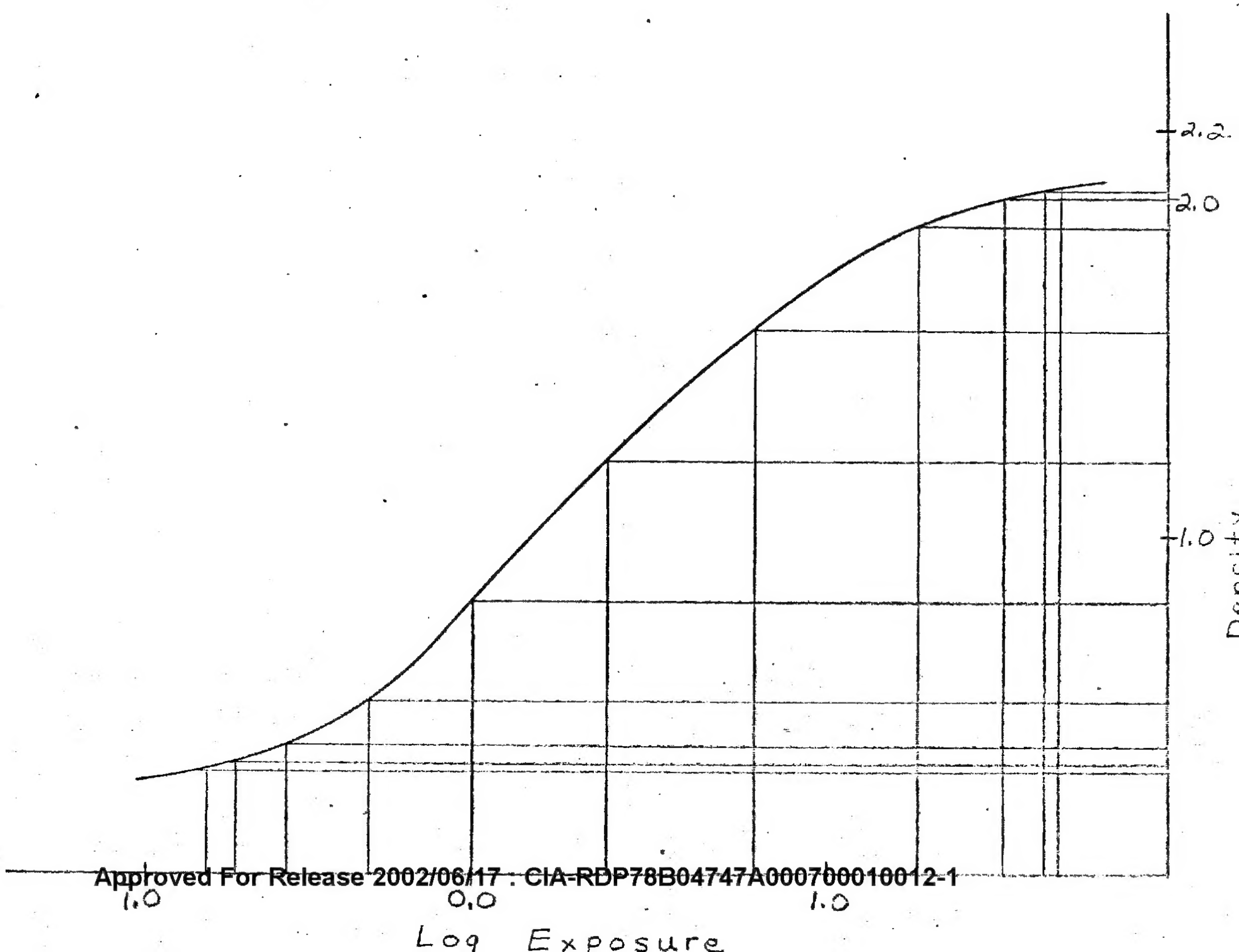
ON on 3404 with
one step $\gamma = 2.3$

FIGURE 1 CASE I ORIG. NEG.



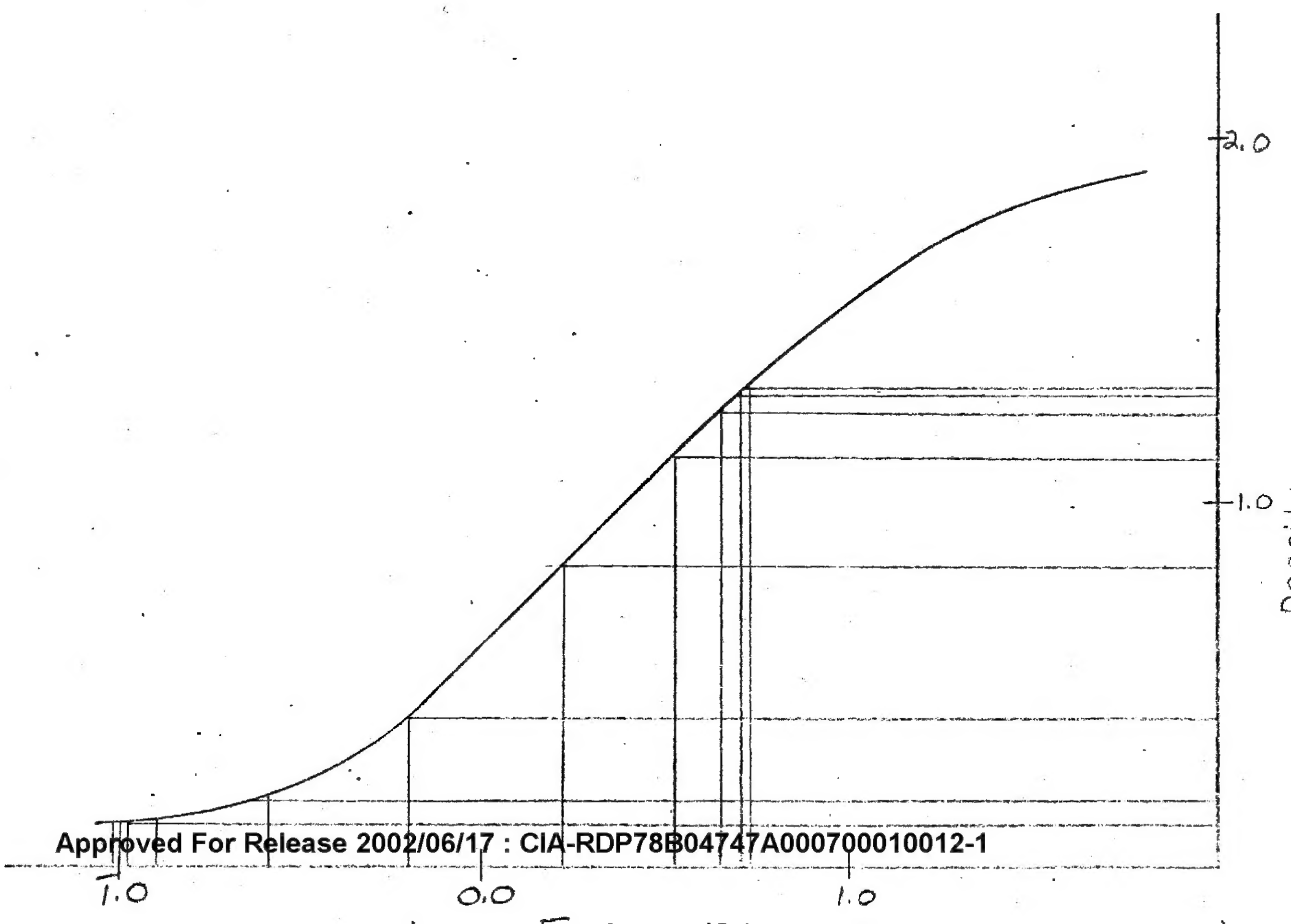
Master on SO 243
with one step $\gamma = 1.0$

FIGURE 2 CASE I MASTER



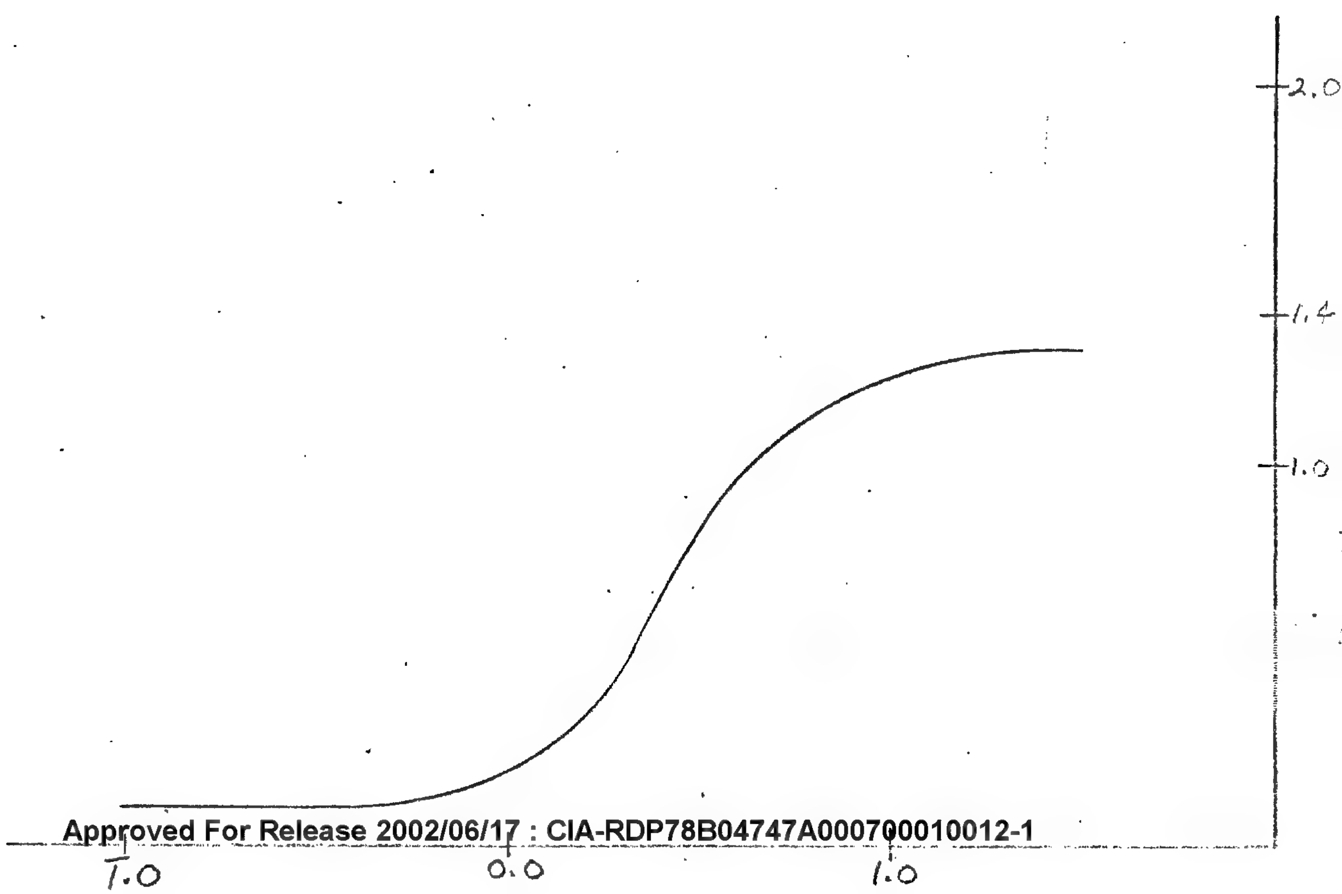
Neg GEMS on 3404
with one step $\gamma = 1.0$

FIGURE 3 CASE I NEG. GEMS



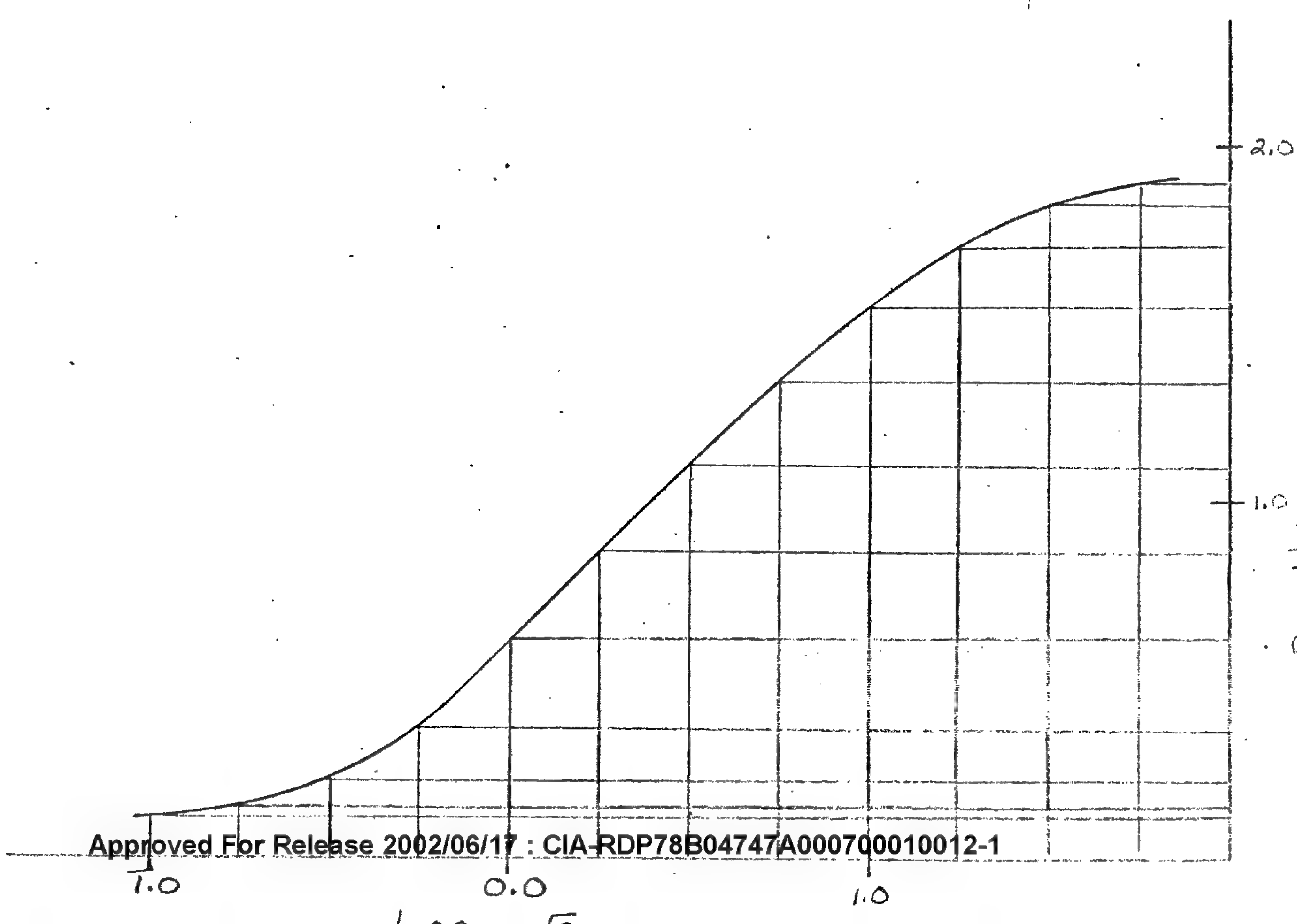
Neg GEMS on 3404
with cascaded $\gamma = 1.8$

FIGURE 4 CASE I CASCADED CURVE



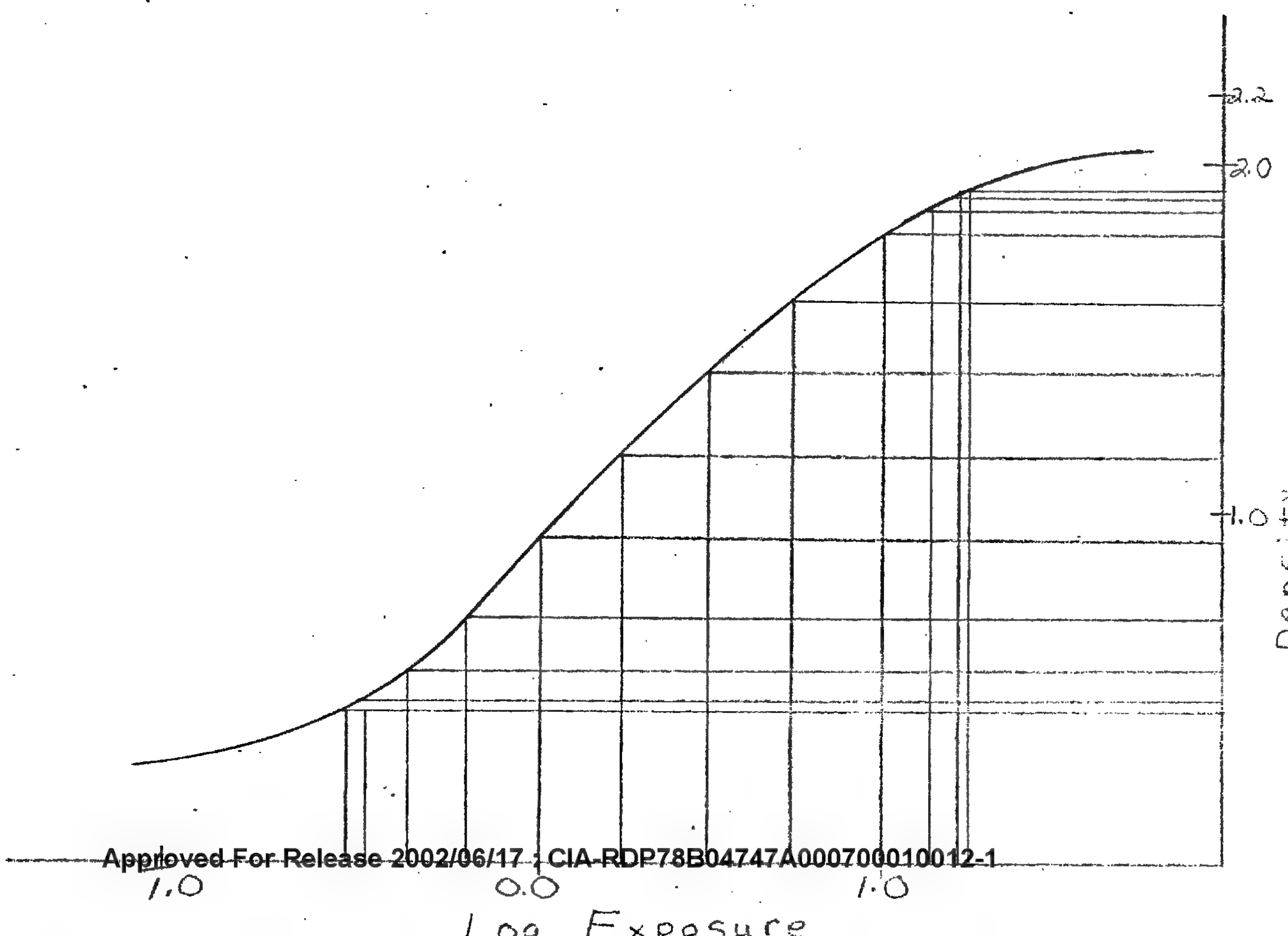
ON on 3404 with
one step $\gamma = 1.0$

FIGURE 5 CASE II ORIG. NEG.



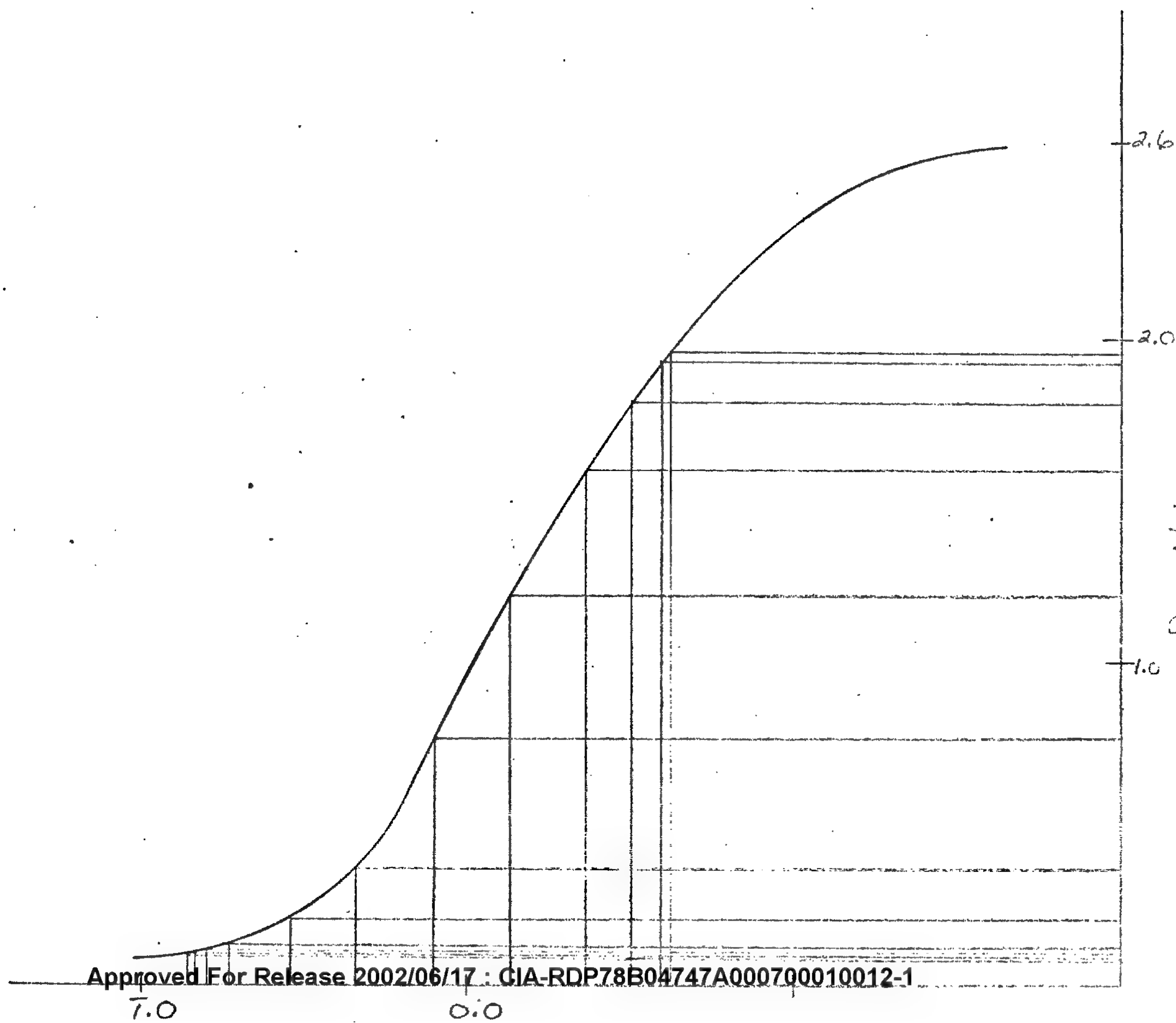
Master on SO 243
with one step $\gamma = 1.0$

FIGURE 6 CASE II MASTER



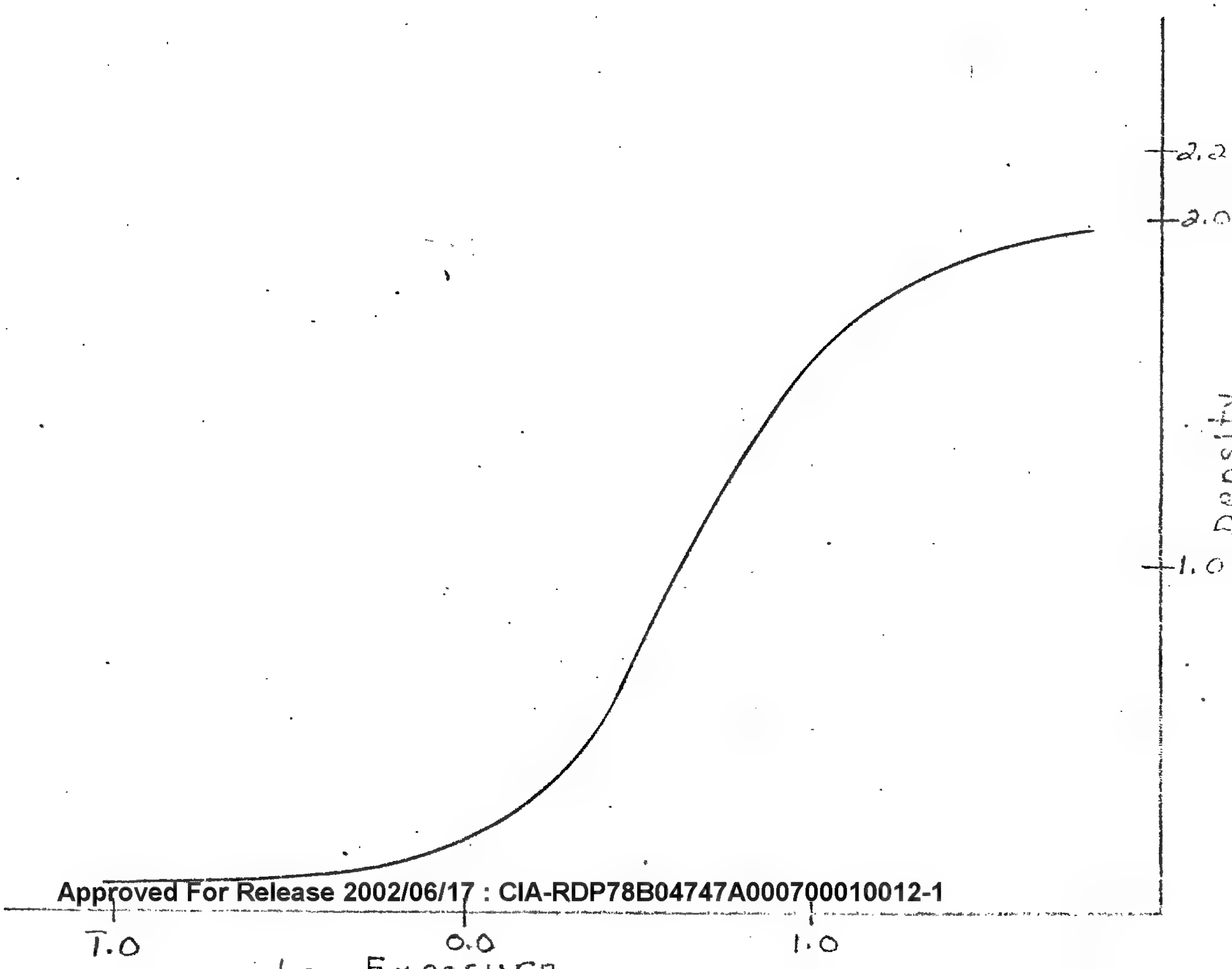
Neg GEMS on 3404
with one step $\gamma = 2.3$

FIGURE 7 CASE II NEG. GEMS



Neg GEMS on 3404
with cascaded $\gamma = 2.1$

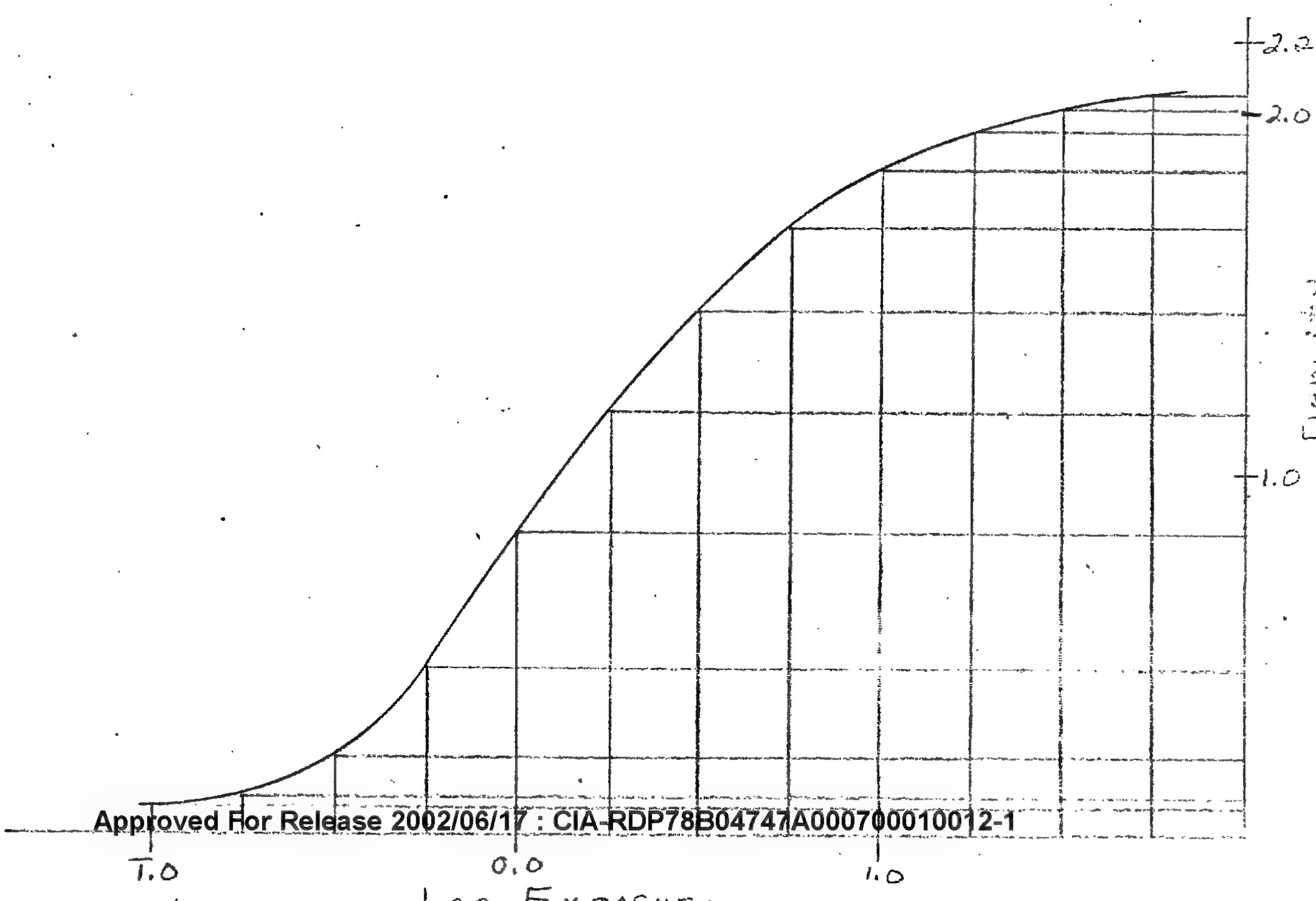
FIGURE 8 CASE II CASCADED CURVE



(15)

ON on 3404 with
one step $\gamma = 1.4$

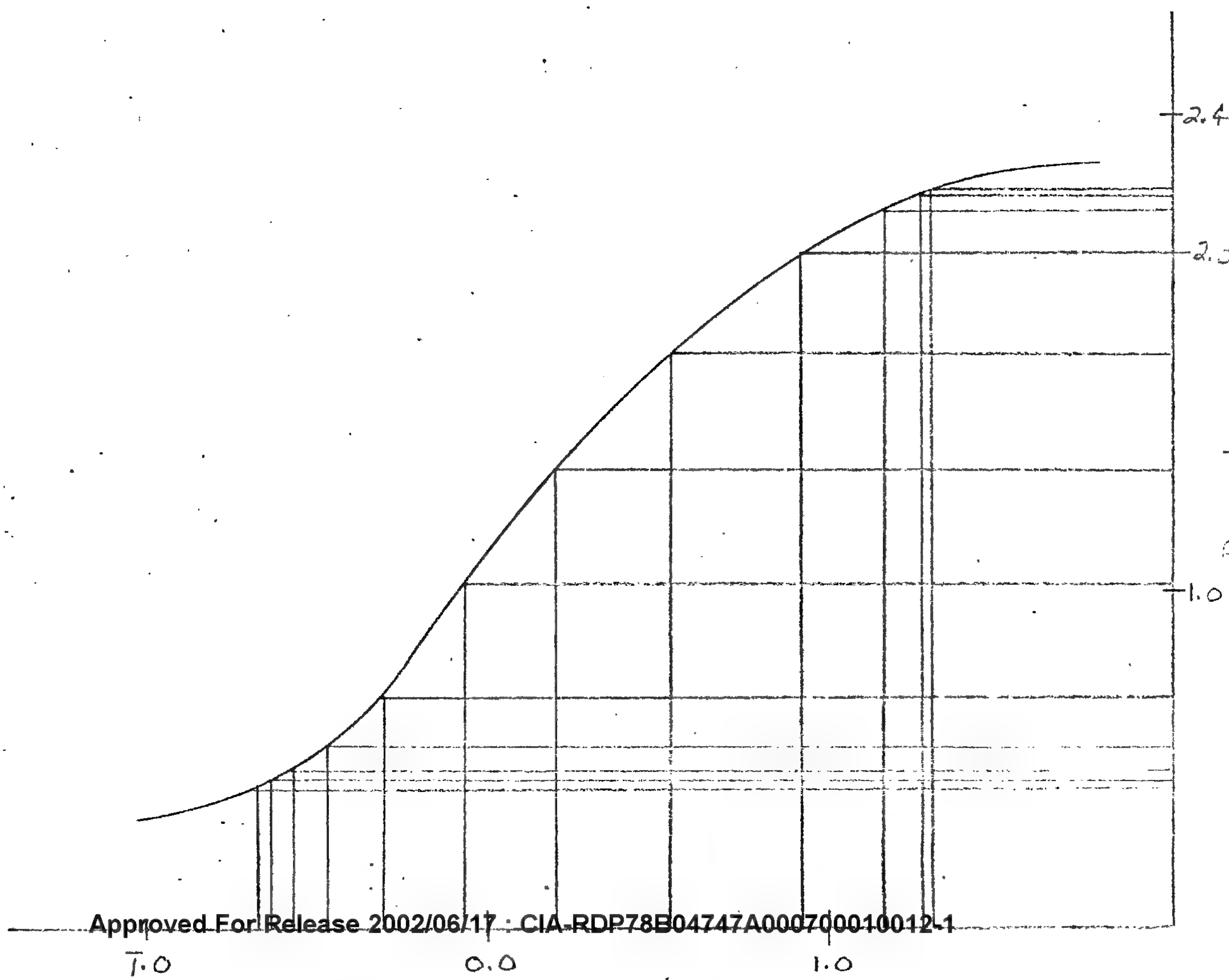
FIGURE 9 CASE III ORIG. NEG.



(16)

Master on SO243
with one step $\gamma = 1.35$

FIGURE 10 CASE III MASTER



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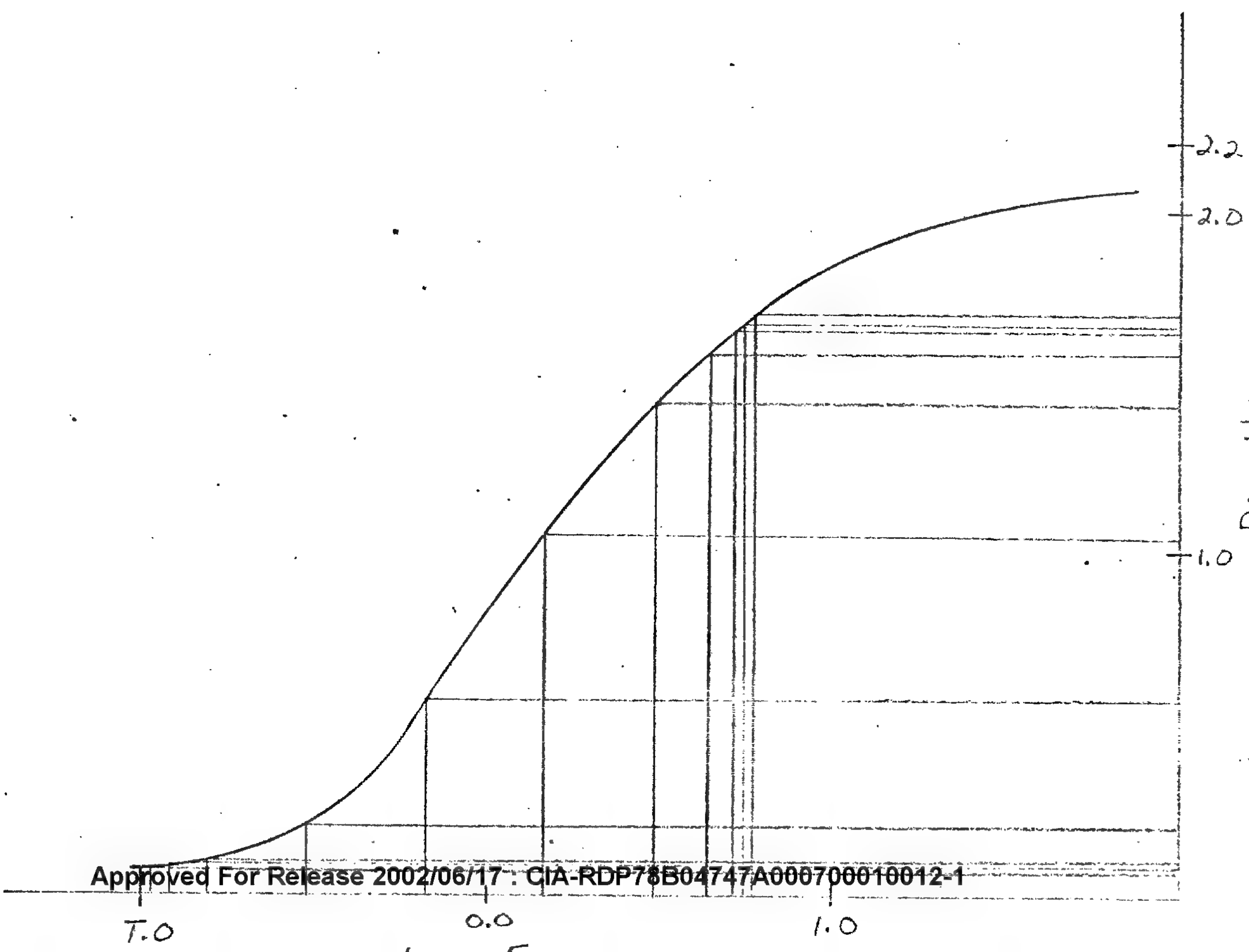
(17)

Neg. GEMS on 3404
with one step $\gamma = 1.4$

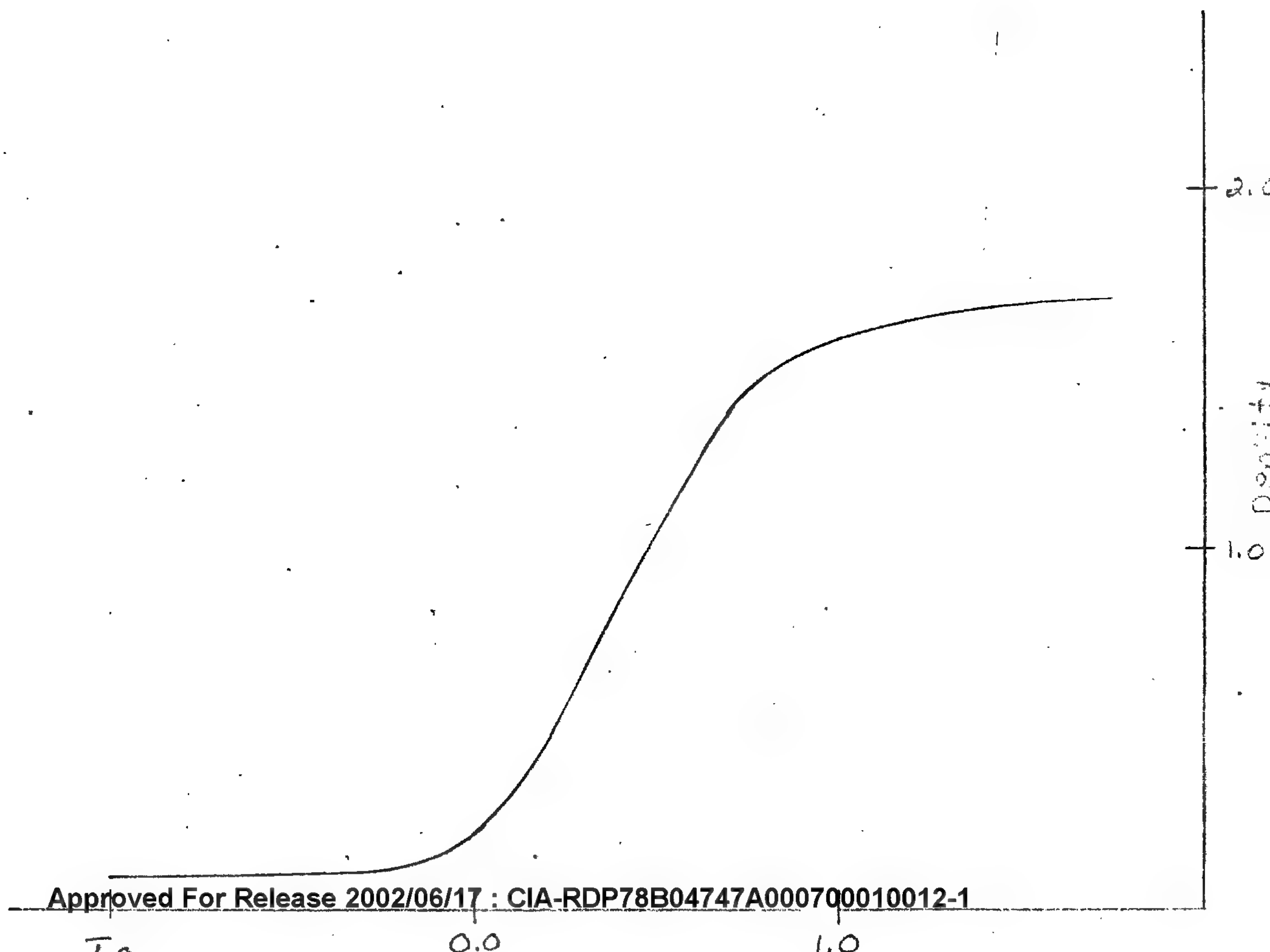
FIGURE 11 CASE III NEG. GEMS



(18)

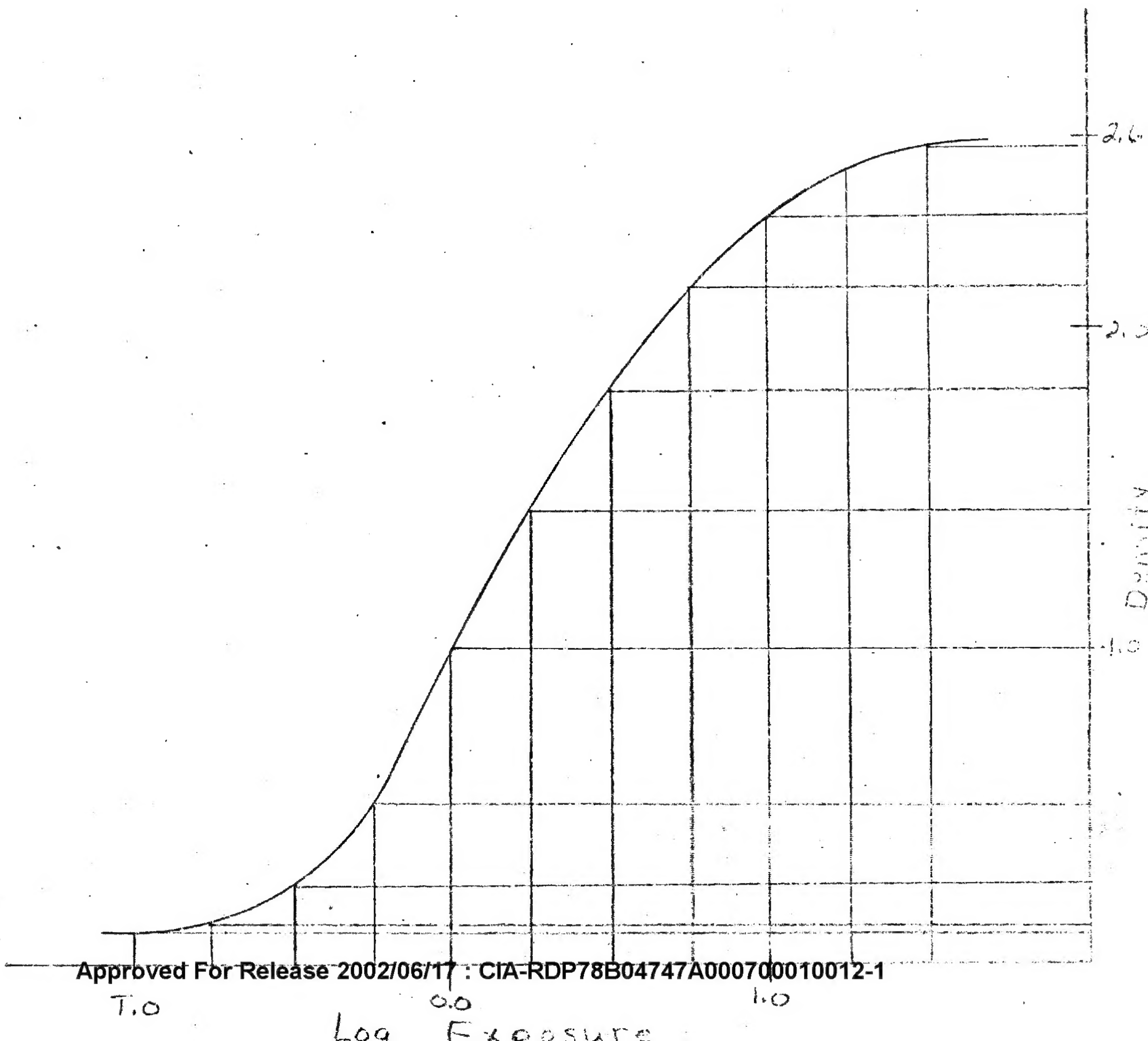
Neg. GEMS on 3404
with cascaded $\gamma = 2.1$

FIGURE 12 CASE III CASCADED CURVE



ON on 3404 with one step $\gamma = 2.3$

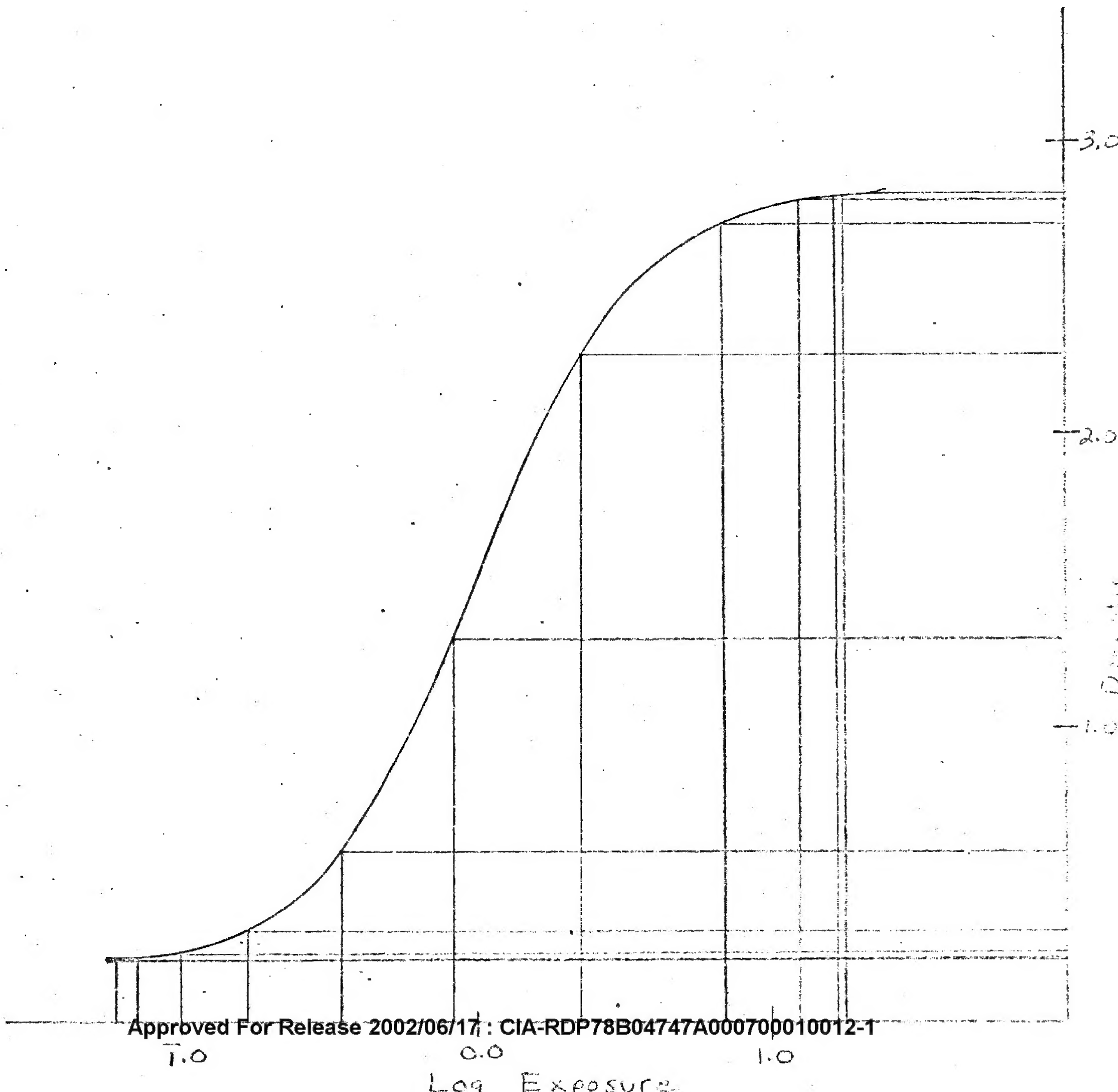
FIGURE 13 CASE IV ORIG. NEG.



Approved For Release 2002/06/17 : CIA-RDP78B04747A000700010012-1

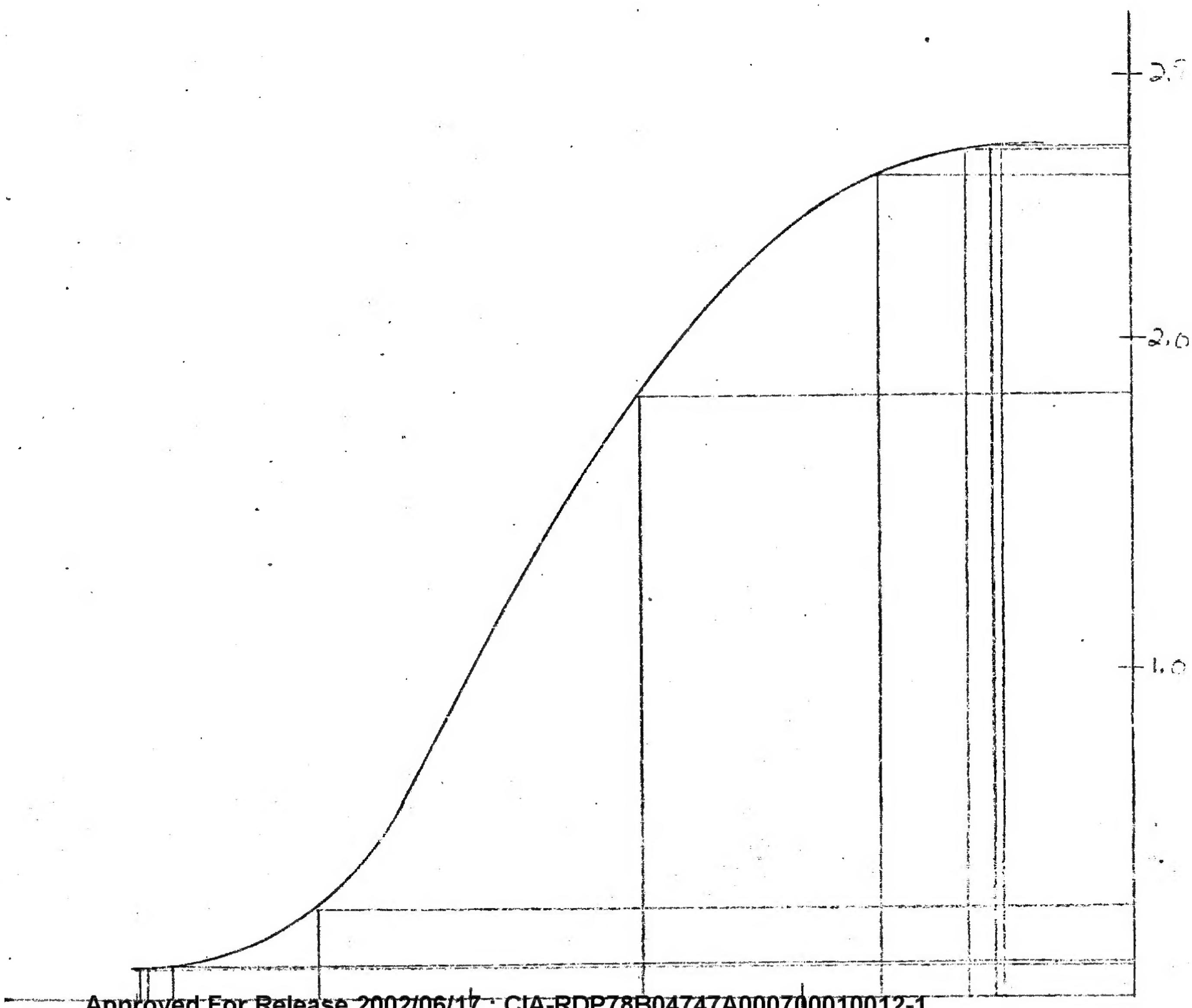
Master on SO 243
with one step $\gamma = 2.3$

FIGURE 14 CASE IV MASTER



Neg. GEMS on 3404
with one step $\gamma = 2.3$

FIGURE 15 CASE IV NEG. GEMS



Log Exposure

(22)

Neg. GEMS on 3404
with cascaded γ of ≈ 8

FIGURE 16 CASE IV CASCADED CURVE